



## **Sub-Milankovich millennial cycles in proxy (UK37) sea surface temperatures for the Okinawa trough, W Mediterranean Sea, NW Atlantic Ocean and Southern Ocean**

Michael Asten

Monash University, School of Earth Atmosphere and Environment, Melbourne, Australia (michael.asten@monash.edu)

Sea surface paleo-temperatures for the Holocene deduced using the UK37 proxy are studied for four sites; the Okinawa trough (IODP hole 1202B); western Mediterranean Sea (Core 293G); NW Atlantic ocean (off-shore Portugal Core MD95-2042); Southern Ocean (off-shore S Australia, Murray Canyon, core MD03-2607). Data lengths are to 100-20K, 100-20K, 100-70K and 1100-134K years BP respectively. The sampling in time provided by the four data sets differs by an order of magnitude, ranging from the very high sedimentation rate in the Okinawa trough (84m of core over 20K years, time samples range from ~20 yr to 100yr over the core length) to modest rate of the Murray Canyon (2.4 m core over 20K yr or 15 m over 134K yr, time sampling ~ 300 yr).

In order to gain information on spectral periods which are a large fraction of the total data lengths, and where Milankovich periods are very dominant, we first pre-whiten data using least-squares methods to fit and subtract Milankovich frequencies associated with earth eccentricity (125Kyr and 95Kyr), tilt (41 Kyr) and precession (23 Kyr and 19 Kyr). The resulting stripped data sets are then subjected to Fourier spectral analysis.

A period of 5-7K yr is strongly present for the three ocean sites but is absent in data from the Mediterranean Sea site. This extends evidence of a 6000 yr cycle which have been reported from sediments off-shore Norway, and adds three examples from non-glaciated localities. A period of 2.3 Kyr, well known as the Hallstat period, is strong in the high resolution data of the Okinawa Trough and west Mediterranean; it is present in the other two sites but as a peak smaller than a longer period of 3-4 Kyr at these latter two sites.

The high resolution Okinawa trough data is striking in that it can be fitted to a high degree of accuracy with just four doublet periods (Milankovich 23-19 Kyr, a possible harmonic 10-12 Kyr, unnamed 6.5-5 K yr, and Hallstat 2.5-2.2 Kyr). The fit to a set of narrow spectral lines adds to the credibility of the hypothesis of an astronomical clock being the source of the sub-Milankovich millennial cycles.

The fitted doublet periods can be projected into the future and indicate (at the Okinawa trough site) a contribution to cooling of 2 degC over the next millennium, compared with the total warming of 4 degC at this site since the Last Glacial Maximum. This estimate is robust when repeated with a data set modified to remove the observed data 0-2K yr and 0-4 Kyr BP.